NASTRAN: A Preliminary Discussion of User Impacts

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Theme

INDUSTRY and government agencies have devoted serious and concerted efforts to developing tools to aid in solving a wide variety of large, structural analysis problems. The NASA Structural Analysis Computer Program (NASTRAN) was specifically designed to provide such a capability. NASTRAN is a general purpose digital computer program designed to analyze the behavior of elastic structures under a range of loading conditions, using a finite-element displacement method approach.[1] Analytical capabilities include 1) static response to concentrated and distributed loads, thermal expansion, and enforced deformation; 2) dynamic response to transient loads, steady-state harmonic loads, and random excitation; and 3) determination of real and complex eigenvalues for use in vibration analysis, dynamic stability analysis and elastic stability analysis. The system has the capability of treating problems of virtually unlimited size, because economic considerations will generally limit the problem size long before reaching the limitations of the NASTRAN algorithms.

NASTRAN is highly user-oriented, which partially accounts for its widespread acceptance and popularity. The program is systematically organized to do much of the work automatically and minimize the burden on the analyst. NASTRAN includes over 151,000 fortran statements, which translate into more than 1,000,000 machine language statements. It is machine independent, with options available for the IBM 360 and 7090 series, UNIVAC 1108 and CDC 6000 series. The NASTRAN program has an extensive plotting capability.

NASTRAN was developed during the period 1965–1970 at NASA's Goddard Space Flight Center at an estimated cost of $3,000,000. Since its release for public use in November, 1970, continued development and management of the program have been transferred to the Langley Research Center. Because it represents the capture of significant secondary returns on the investment of the public research and development dollar, NASA has sponsored a study to survey the extent of the usage of NASTRAN and estimate some of the benefits that have accrued to users. In addition, information has been compiled regarding costs of performing certain applications, as well as new improvements or adaptions which have been developed by users. The following are the major results of that study.

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Usage. As one of the most comprehensive, general purpose computer systems for structural analysis in existence today, NASTRAN is enjoying widespread acceptance throughout industry and government. There are currently 186 applications reported to be in progress and 55 applications planned by the 152 respondents to the survey. The importance of NASTRAN to the engineering community is evidenced by the users' view that two-thirds of the current applications would not have been attempted without it. At the time of the study, at least 667 persons (mostly engineers) were involved in the use of NASTRAN, and at least 21 service bureaus were furnishing NASTRAN services to other organizations. Additional user interest and involvement were shown by the respondents' recommendations for 35 future applications and 116 suggestions for improvements in the program.

Cost. NASTRAN is available publicly from the NASA-sponsored Computer Software Management and Information Center (COSMIC), Barrow Hall, University of Georgia, Athens, Ga., 30601. The average cost for a complete set of tapes and documentation is $1700, depending on the options required by the user, and program maintenance is furnished to NASTRAN purchasers. Major updates or new releases of the program are made in numbered stages (called levels); the current NASTRAN level is 15.0. Level 15.5 will be issued in the early spring.

NASTRAN users have reported spending over $529,000 for some 50 applications; extrapolating this figure to 186 applications indicates that over $1.5 million has been spent in the use of NASTRAN. Table 1 presents the costs of performing some selected NASTRAN applications by the aerospace industry. In addition to the $80,900 invested by aerospace users on new program improvements and adaptations, $151,000 was reported to have been spent for that purpose by government agencies and service bureaus, making the estimated total $232,000 invested by individual organizations for their own improvements or adaptations.

Seven of eight cost comparisons between running the same application with NASTRAN and another program were favorable to NASTRAN, although the data in these examples are limited. A discernable trend seems to emerge: the number of man hours is reduced with NASTRAN, but computer running time is increased. However, considerable running time reductions are expected in the near future with the introduction of level 15.5.

Benefits. The most significant direct economic benefits to NASTRAN users are attributed to substantial increases in productivity, which have enabled significant reductions in real operating costs. Four primary factors, listed as effecting the increases, are 1) analyses have been accomplished which could not have been done without NASTRAN; 2) more complete and accurate results have been obtained; 3) development time has been shortened; and, 4) communications between engineers and programmers have been improved because of the standardization of technology and mathematical approaches developed in NASTRAN.

Cost savings have also accrued to NASTRAN users from NASA program maintenance. Eighty percent of the users responding to a question regarding benefits in this area reported they achieved actual cost savings which were directly attributable to the provision of maintenance of the program by NASA. The savings for 27 applications were estimated to be $324,000; when extrapolated over 186

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Table 1 Costs of performing selected NASTRAN applications in the aerospace industry

Application	Programmer/ analyst cost	Engineer cost	Computer cost*	Total
Structural response	$ 0	$ 4,400	$ 9,000 (a)	$13,400
Buckling of motor case	0	10,000	4,000 (a)	14,000
3-D propellant stress and response	400	3,000	800 (a)	4,200
Differential stiffness	50	350	100 (b)	500
½ reflector with some rigid joints	700	2,700	4,000 (b)	7,400
Antenna quad: static analysis and natural frequency	100	900	500 (b)	1,500
Antenna structure	0	1,400	500 (b)	1,900
Dynamic stress concentration	4,600	5,800	13,000 (c)	23,400
ATM solar array (static)	0	25,300	24,000 (b)	49,300
ATM solar array (dynamic)	0	5,200	3,000 (b)	8,200
C&D logic assembly (dynamic)	0	7,200	3,000 (b)	10,200
Antenna range tower	0	16,800	6,000 (b)	22,800
Drone fuselage	3,300	12,000	2,850 (d)	18,150
Drone wing	1,500	5,250	2,150 (d)	8,900
Drone wing modification	0	250	60 (d)	310
Truss buckling	0	11,700	4,500 (e)	16,200
Aircraft canopy	0	1,500	600 (f)	2,100
Aircraft wing	0	500	75 (f)	575
Aircraft fuselage	0	700	150 (f)	850
Test structure	0	700	300 (f)	1,000
Composite speedbrake	0	1,100	300 (a)	1,800
ASIP program—normal modes	0	1,100	1,000 (a)	2,100
Space shuttle—normal modes	0	6,400	8,000 (a)	14,400
Space shuttle—transient response	0	2,300	1,500 (a)	3,800
RAM program modes	0	500	600 (a)	1,100
Antenna study modes	0	1,400	2,500 (a)	3,900
CH53 sponsor analysis	2,000	6,000	4,000 (g)	12,000
Fuselage center section CH53E	1,000	6,000	2,000 (a)	9,000
AARS fuselage studies	0	5,000	4,000 (a)	9,000
UTTAS fuselage	0	6,000	10,000 (a)	16,000
Total	$16,350	$161,850	$117,125	$295,325

*Computer model: (a) CDC 6600; (b) UNIVAC 1108; (c) IBM 360/65; (d) IBM 370/155; (e) IBM 360; (f) IBM 360/75; (g) IMB 360/67.

current applications and about 55 planned applications, approximately $2.5 million are being saved annually by NASTRAN users on program maintenance.

In addition to enabling operating cost reductions, NASTRAN was found to have contributed to new product development. Although the data in this area were limited, three examples of new product development attributable to NASTRAN in the aerospace industry are 1) hypersonic wing—$650,000 value; 2) engineering support services—$40,000 value; 3) analysis of complete electronic packages without need to substructure—$15,000 value annually.

Some other areas where significant benefits were reported to have been obtained are 1) better quality assurance—savings of $12 million annually by a major nonaerospace company; 2) improved reliability analysis—savings of 500 man-hours by a NASA group; and, 3) development time—savings of eight weeks for an aerospace firm.

This study of user experiences is useful in demonstrating the value of the concept, which forms the basic mission rationale of NASA's Technology Utilization Program, that an active program to transfer the technology developed to meet aerospace requirements to other economic sectors does have a significantly beneficial effect on productivity and economic growth. In the case of the NASTRAN program, the transfer has been particularly successful and the economic impact has been shown to be substantial.

References

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